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FARMERS' BULLETIN 306.

DODDER IN RELATION TO FARM SEEDS.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 1, 1907.

Sir: I have the honor to transmit herewith a paper by Mr. F. H. Hillman, Assistant Botanist in the Seed Laboratory, entitled "Dodder in Relation to Farm Seeds."

Dodder, on account of its parasitic nature, is the most dangerous weed in alfalfa and clover fields, and also often affects flax. On account of the large quantity of low-grade seed containing dodder imported from Europe and the prevalence of dodder in the alfalfa-growing regions of the West, its seed is becoming more and more common in commercial seeds.

In this paper an attempt has been made to point out the dangerous character of the various kinds of dodder and to give practical suggestions for the eradication of dodder from infested areas.

I recommend that this paper be published as a Farmers' Bulletin.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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DODDER IN RELATION TO FARM SEEDS.

INTRODUCTION.

It is probable that commercial seeds representing forage crops, especially the clovers and grasses, are the most effective medium through which weed seeds are disseminated. The custom in vogue in this country and in foreign countries of producing seed of these crops as a secondary feature of their culture and without special attention to the character of the foreign plants which may grow with the crops is chiefly responsible for the great number and variety of weed seed impurities commonly disseminated in the product. Such foreign seeds are characterized primarily by ripening at about the same time as the crop, and as they possess a similarity to the crop seeds in size and weight they are not readily removed by the sifting accompanying the thrashing of the crop. It is in this way as incidental to the culture of certain crops that the seed of dodder or love vine becomes an impurity of certain kinds of commercial seed.

Dodder is not in itself a means of direct seed adulteration, but as a very common impurity of low-grade seed it becomes a prominent feature of adulteration when such seed is used as the adulterant.

Dodder, especially as a menace to clover and alfalfa culture, is becoming more and more prevalent throughout the country and is everywhere commanding attention from farmers who are observant of conditions affecting their crops.

The most important step in controlling the dodders is to prevent, if possible, the introduction of their seeds in commercial seed. While absolute freedom from dodder in farm seed can not be assured, proper care on the part of the purchaser can reduce to a minimum the chances of dodder introduction. This involves the recognition of the dodder if present in seed and the recleaning or rejection of the latter, as the case may require.

The farmer should know what crops are liable to damage from dodder, to what extent their seeds carry dodder seed, that several kinds of dodder are involved, that the source of the crop seed influences the kind of dodder likely to be present, that dodders have very pronounced host preferences, that dodder seed production may be influenced by climatic conditions, etc.

DODDER AN IMPORTANT IMPURITY IN SEEDS.

The seed of dodder becomes an important impurity of commercial seeds both on account of the injurious nature of the plants and the fact that they occur in nearly all the regions where clover, alfalfa, and flax seeds are produced. The size and weight of the dodder seeds and the period of their maturity agree so closely with those of red clover and alfalfa seeds that their presence in the seed crop is practically sure to follow the occurrence of maturing dodder plants in fields devoted to these crops. The same is true of flax seed which has not been especially well cleaned. The extent to which dodder may infest clover and alfalfa seed is indicated by the fact that of 521 samples of red clover seed secured by the Seed Laboratory in the open market in the spring of 1906, 116 samples contained dodder. Again, of 352 samples of alfalfa seed 160 contained dodder.

Clover and alfalfa seeds as sold to farmers have frequently followed a devious course from the grower to the consumer and are especially likely to represent a mixture of lots from different places of production. If one ingredient of such a mixture is infested with dodder the whole becomes contaminated. Not many dodder seeds may occur in a particular lot bought by a farmer, to be sure, but owing to the peculiar nature of the dodder plants a single live dodder seed in a field is a menace to the entire crop.

It is very important that the farmer purchasing clover, alfalfa, or flax seed be qualified to determine for himself whether dodder is present, because it usually is not conspicuously abundant and may escape the notice even of the most conscientious dealer.

SENTIMENT REGARDING DODDER IN EUROPE.

The dangerous character of the dodder plants as pests of flax and leguminous crops, together with their wide distribution throughout the regions which have long grown these crops, especially in Europe, has caused them to be looked upon with dread by farmers. The result is that under the existing seed-control regulations generally in vogue in Europe dodder seed as an impurity of commercial seeds is singled out for special consideration and seed containing it is usually rejected. Reports upon seed tests at the European seed-control stations usually make particular reference to the presence or absence of dodder. As a result of its unpopularity seed containing it is practically unsalable in the domestic trade of most of the European countries.

It is owing to this adverse sentiment in Europe regarding dodder-infested seed and the absence in this country of a national law prohibiting the importation and sale of such seed that so much dodder is annually distributed throughout the United States.

THE CHARACTER OF DODDER PLANTS.

Dodder is a parasite deriving its food not from the soil, but directly from the crop plants which it infests. In this respect it is unlike the ordinary weeds of the farm. It starts from a seed, at first deriving its nourishment from the food supply stored within the seed. During this period it develops a slender, threadlike, and leafless stem. It is the habit of the dodder to climb by twining, and the young stem sways about in search of a support. Failing to find a suitable support it dies when the food stored within the seed is exhausted. If a suitable support, such as the stem, leaf stems, or even leaf blades of a clover, is found, the dodder rapidly twines about it, sending out from its stem numerous suckers which penetrate the tissues of the plant upon which it rests, termed the host plant. The dodder is subsequently dependent on its host for both its mechanical support and its food supply. The twining of the dodder stem and the clinging effect of the suckers secure the mechanical support necessary, while the penetration of the suckers to the sap-conveying tissues of the host plant insures direct communication with the food prepared by the latter for its own use.

After becoming established on the host plant the part of the dodder plant below the point of attachment dies. Above this point the plant makes rapid growth, branching repeatedly, its branches ultimately forming a tangled mass of threadlike filaments when under conditions favorable for luxuriant growth. At first the growth is apparently insignificant, but with the rapid increase in the branching the total growth soon becomes very conspicuous, and in some instances progresses with exceptional rapidity, rendering its control very difficult.

Dodder depends on prepared food. Independent food manufacture becomes unnecessary, and consequently the plant is devoid of leaves, as well as of root, and usually is devoid of the green color common to other plants. Certain species are strongly tinged with green, however, and doubtless are capable of food production to some extent.

Sections of the dodder stems removed from the main plant retain their vitality and power of coiling and producing suckers for several days at least under favorable conditions. In consequence of this, if pieces of plants are allowed to remain in contact with a suitable host plant for a short time they become attached to the latter and form new centers of growth. In this way new patches of the pest may become established in the field.

Dodder plants are to be distinguished by their slender, threadlike stems, which are lemon yellow, orange, or pink. They may appear to confine their attack to a single plant in a place or may spread uniformly from plant to plant, either near the ground or from the tops of the plants. Small white flowers, mostly in clusters, are produced

by midsummer. The flowers may be few and scattered, or, owing to thrifty growth, they may be more numerous and, becoming crowded, form dense bunches. (Fig. 1.)

FIG. 1.—Field dodder on red clover; *a*, Flowering cluster; *b*, cluster of dry seed vessels. From a photograph. Natural size.

Seeds ripen throughout the central United States from the middle of July into September. As a rule, the dodders are profuse seed producers, but seed production is strongly influenced by the character

of the host, its treatment as a crop, and by the condition of the weather during the flowering season of the dodder.

THE VARIOUS KINDS OF DODDER.

Farmers commonly look upon dodder as representing but one kind of plant. On the contrary, there are several kinds which infest leguminous crops, irrespective of the kind infesting flax. This discussion relates in the main to the class of dodders whose seeds are carried by commercial seeds, but it may be said that there are other kinds indigenous to certain parts of the country which are more or less injurious. These kinds attack certain cultivated plants which may be brought near them. If the seeds of such cultivated plants are not in the trade, the dissemination of the dodders affecting them is accomplished by the transmission of plants or cuttings bearing living pieces of the dodder.

As a matter of passing interest, it may be stated that aside from the injurious kinds of dodder there is a large number of kinds which have no recognized relation to cultivated plants or crops. They live on various wild plants, and it is the common experience of those who frequent fields and uncultivated lands to meet one or more of these kinds of dodder which command the attention of the most unobserving person by their peculiar threadlike, tangled stems.

KINDS OF DODDER SEED INFESTING FARM SEED.

There are at least six different kinds of dodder whose seeds are commonly disseminated in commercial seeds and therefore are worthy of the farmer's consideration, as follows:

(1) Flax dodder (*Cuscuta epilinum*) is a parasite on flax especially. It sometimes infests other plants, including certain shrub fruits, but it is not a pest of clover or alfalfa fields. It occurs in foreign countries and also in those States where flax is grown in this country. The other kinds of dodder under discussion are all parasites on clover or alfalfa, or on both, but do not infest flax.

(2) Clover dodder (*Cuscuta epithymum*, often referred to as *Cuscuta trifolii*) infests both the true clovers and alfalfa indiscriminately. It is widely distributed in foreign countries and in the United States east of the Mississippi River and in the Northern Pacific States.

(3) Small-seeded alfalfa dodder (*Cuscuta planiflora*) as it occurs in this country appears to confine its attacks to alfalfa in preference to the true clovers. Thus far there is no evidence of any damage from this dodder to red, alsike, or white clovers. This is by far the most abundant and destructive of the dodders in the Western States.

(4) Field dodder (*Cuscuta arvensis*, as recognized in the botanies) is widely distributed throughout the United States. It infests both the

clovers and alfalfa and also many wild herbaceous plants. It has proved injurious to sugar beets in Utah.

(5) Large-seeded alfalfa dodder (*Cuscuta indecora*) is common in the West, especially in Utah. It infests alfalfa as well as various wild plants, but it does not appear to damage the true clovers.

(6) Chilean dodder (*Cuscuta racemosa chilcana*) is not generally known in this country. It is common in South America and has been reported from Europe. It is said to have flourished for a time in California many years ago, but subsequently disappeared. It is of interest because of its prevalence in alfalfa and red clover seed-producing regions of South America from which seed is being sent to the United States, for this dodder infests both alfalfa and red clover. Little is known of this dodder in its relation to forage crops in this country, but since it is being brought here in considerable quantity from South America it is very likely that it will become one of the several injurious species established in the United States.

PREFERENCE OF THE DODDERS FOR CERTAIN HOST PLANTS.

The dodders exhibit a peculiar preference, so to speak, for certain plants over others as hosts. It is more evident with some dodders than with others, and in consequence certain kinds have come to be popularly designated in accordance with this evident preference. This fact has been so long recognized that in some instances the Latin names were selected with regard to it. Thus the dodder universally attacking flax is known as flax dodder in several languages, and its habit of infesting the flax crop is expressed in its Latin name *Cuscuta epilinum*, since flax belongs to the botanical genus Linum. Another kind known thoughout Europe and in this country as clover dodder has been generally recognized by botanists under the Latin name *Cuscuta trifolii*, given to it in recognition of its preference for the true clovers, which belong to the genus Trifolium.

This host preference becomes of interest from a practical standpoint from the fact that certain classes or kinds of crops are subject to infestation, while others are not. Thus, of the forage crops the leguminous plants are infested, while the grasses are not affected, to a material extent at least.

Notwithstanding this more or less decided selective power exhibited by the dodders toward host plants, they will attack other kinds of plants under favorable conditions and for a time derive their nourishment from them. They are very likely not to thrive, however, and often do not produce flowers and develop seeds when on such hosts. Clover dodder, for instance, will be found growing on various grasses and weeds among the clover plants of a field, yet when the clover succumbs to the dodder such grasses and weeds begin to thrive, the

dodder they have supported largely or wholly disappearing. On the other hand, the small-seeded alfalfa dodder of the West confines its attacks almost exclusively to alfalfa, other plants in the field as a rule being immune to it. Field dodder is more indiscriminate in its preferences. While it grows actively on various wild plants throughout the country, it is a most luxuriant and destructive pest of both clover and alfalfa.

KINDS OF SEEDS INFESTED WITH DODDER.

The host preference possessed by the dodders limits both the kinds of seeds which carry dodder seed and the kinds of dodder disseminated in this way. Both are further limited by the relative sizes of the seeds of the host and of the dodder.

Dodder seed dissemination as a seed impurity is practically restricted to the seeds of flax and of leguminous crops or to seed mixtures in which leguminous seed forms an ingredient. Most of the leguminous crops may be subject to dodder infestation, but it is confined chiefly to those whose period of ripening coincides with that of the dodder and whose seeds are small enough to admit the dodder seeds as an impurity. This restricts the list of seeds for this country to flax, the red clovers, alsike clover, white clover, and alfalfa. To these may be added yellow trefoil, which as an adulterant frequently used may introduce dodder to otherwise dodder-free clover or alfalfa.

The list of leguminous seeds mentioned as subject to dodder infestation is given because tests of these seeds have shown that dodder is at least sometimes present in all of them. The source of the seed at once becomes important in this connection, because American-grown alsike and white clover seeds rarely, if ever, contain dodder, while those produced in Europe often contain it. Again, the place of production of red clover and alfalfa seeds has a most important bearing on the probability of the presence of dodder seed, its kind and quantity. Dodder as a seed impurity becomes from a practical standpoint of most interest to the American farmer in its relation to red clover, including the mammoth variety, and to alfalfa. With regard to these kinds of seeds the presence of dodder becomes a serious matter and in the purchase of seed is always worthy of careful consideration.

RELATION OF DODDER TO THE SEED TRADE.

The most direct relation between dodder seed and the business of seed buying and selling is based upon the regions of growth of the dodder and the size of its seed as compared with that of the commercial seeds handled. The kind of dodder is largely influenced by the place of seed production, while the size of the dodder seed, which is

dependent chiefly on the kind, has much to do with the result of efforts at recleaning and the consequent condition of the seed when it reaches the consumer. Large quantities of the flax, clover, and alfalfa seeds on the American market are imported, often from regions where certain kinds of dodder are abundant.

REGIONS OF SEED PRODUCTION.

With regard to flax seed little is to be said of the relation of the place of production and flax dodder. This dodder is so widely prevalent in flax regions that its presence in flax seed is always possible.

Red clover seed is imported largely from Germany and to some extent from France, England, and Canada. Chilean red clover seed grown in South America is being imported in considerable quantity. There is also an active domestic traffic in red clover.

Alsike clover seed when imported comes chiefly from Ontario, very little being imported from Europe. It is also produced in the northern United States.

White clover is often imported from Europe, but is also produced in this country.

Crimson clover, which figures largely in the import as well as the domestic trade, bears practically no relation to dodder dissemination when not adulterated, owing to its early seeding period, which precedes that of the dodders by a month or more. Dodder seed, therefore, practically never appears in pure crimson clover seed.

Alfalfa seed is imported from Germany, southern France, Italy, Turkestan, and Argentina. Much of the seed used in this country is produced in the Western States, particularly Utah, Wyoming, and Colorado.

Seed reaching the consumer may have come from any one of the regions just mentioned, or, if mixing the seed is practiced by the dealer, more than one region of production may be represented by the seed purchased.

Clover dodder is so widely distributed that it is liable to appear in clover or alfalfa seed from almost any source. It is commonest, however, in seed from Europe. This dodder grows in Canada; but little, if any, clover dodder is found in Canadian seed of red clover or alsike clover. While it is known that this species of dodder produces seed in this country to some extent, the fact remains that very little, if any, of its seed appears in American-grown clover or alfalfa seed.

Small-seeded alfalfa dodder is very common throughout the alfalfa-producing States of the West. It often totally destroys fields of alfalfa, while others continue to produce hay and seed for a long time after becoming infested. So abundant is this dodder in some cases that the seed crop, according to statements made to the writer by

ranchers in Utah, often contains from 10 to 20 per cent of dodder seed. This is mostly removed from the alfalfa before it is marketed. One farmer producing large crops of alfalfa seed in Weber Valley, Utah, told the writer that he obtained 60 bushels of dodder seed by recleaning his alfalfa-seed crop for 1904. The condition of his own and the neighboring fields gave excellent support to his statement.

The native home of this alfalfa dodder is in the region of the Mediterranean Sea. Comparatively little alfalfa seed comes to America from the Mediterranean region of Europe, so this dodder is rarely, if ever, found in European alfalfa seed; neither has it been found in South American seed. Turkestan alfalfa seed often contains the seeds of a dodder which appears to be a form of this species.

Field dodder is widely distributed within the United States and its seed is a common impurity of both red clover and alfalfa of domestic production. This dodder is supposed to be an indigenous species, but owing to the fact that much clover and alfalfa seed produced here is exported to foreign countries it is probable that seed of this species is now coming back to us in imported seed. Unless another very similar species of dodder be involved it may be said that field dodder is a common impurity of red clover and alfalfa seeds from nearly all places of production, including the Chilean seed from South America.

Large-seeded alfalfa dodder is found thus far exclusively in alfalfa seed from the western United States, particularly Utah. It does not appear in seed from Europe, although it might be looked for in seed from France, where it is probably the species said to have come from the United States and which is referred to as *Cuscuta gronovii*.

Chilean dodder is common in red clover and alfalfa seeds from Chile and Argentina. It is not known that its seeds occur in domestic-grown seed.

COMPARATIVE SIZES OF SEEDS.

Seeds of the same kind of dodder always differ somewhat in size. The difference is more pronounced in some kinds than in others. There is a more marked difference, however, in the average size of the seeds of different kinds.

While there is similarity in size between the seeds of the various clovers and alfalfa, there is sufficient difference between the kinds and between the largest and smallest seeds of each kind to strongly influence the question of dodder infestation.

The abundance or even presence of dodder in farm seeds is therefore largely dependent on the relative sizes of the two kinds of seed. The combination of the smallest seeded dodders and large-seeded commercial seeds renders successful recleaning possible, while the presence of the larger seeded dodders, especially in small-seeded grades of commercial seeds, gives a practically hopeless mixture.

First-class red clover seed or alfalfa seed should be free from clover dodder. Such alfalfa seed from the West should be free from the small-seeded alfalfa dodder. The large-seeded alfalfa dodder can be only partially removed from average-sized alfalfa seed. Field dodder should be largely removable from the best alfalfa seed, but doubtless can not be even partially removed from any except the large-seeded grade of red clover seed. It is not likely that the seed of any of the dodders can be wholly removed from infested alsike and white clover seed. Pure crimson clover seed, as previously stated, is not under consideration, owing to its early maturity. Such seed should be free from dodder, but if imported yellow trefoil or red clover screenings are used as an adulterant, which form of adulteration appears probable in some instances, dodder may readily be introduced in this way. Clover dodder has been found to be the kind involved in such adulteration. Thorough recleaning in which the trefoil or red clover and the smallest crimson clover seeds are discarded would remove all of this dodder.

Owing to the wide distribution of clover dodder and the small size of its seeds, it becomes the commonest of the various kinds found in commercial seeds. This is largely the result of the use of low-grade seed and screenings.

The question before the seedsmen regarding freedom of seed from dodder is seen to relate not only to the source of the seed, but very largely to its quality and to the size of individual seeds.

It would seem that attention to the stock with regard to its source and the kind or kinds of dodder it may contain would tend to improve the quality of seeds offered for sale. Such consideration certainly could prevent the mixing of lots some of which are free from dodder or contain a kind which is readily removable if present. Careful attention to individual lots of dodder-infested seed could be made to yield a smaller bulk of high-grade dodder-free seed worthy of a correspondingly higher price.

Lastly, the whole matter can be controlled by the dealer whose purchasing agents are personally familiar with the different kinds of dodder in the field and who, guided by this knowledge, will buy only dodder-free crops or such as contain only those dodders whose seed is removable in recleaning.

A KNOWLEDGE OF DODDER SEED OF VALUE TO THE FARMER.

Since seed from different regions is likely to contain dodder of different kinds, the kind has considerable weight as indicating the source of the seed. Indeed, if carefully considered a knowledge of the kinds of dodder seeds is very valuable in determining the region where the crop seed was grown. The purchaser is thus enabled to decide whether

the seed is of domestic or of foreign origin and in some instances to determine the part of the country from which it comes.

The custom of seed mixing to establish a certain trade grade is often very evident in the character of the dodder the seed contains.

Recognition of the several kinds of dodder seed is essential as preliminary to practical methods of recleaning dodder-infested seed. It is furthermore of interest with regard to the relative importance of the several kinds respecting different host plants and climatic conditions, since we have reason to believe that certain species are less injurious under certain conditions than under others.

Ready recognition of the seeds of the different kinds of dodder is essential to these ends. This is easily accomplished in the main so far as practical requirements are concerned.

HOW THE SEED OF DODDER MAY BE DETECTED.

Detection of the presence in commercial seed of dodder, irrespective of its kind, demands first consideration, because its presence justifies refusal to purchase such seed. A magnifying glass is necessary, as it will enable one to readily distinguish any kind of dodder seed from clover, alfalfa, or flax seed. Dodder seeds are, as a rule, about the same size as red clover seeds, including the smallest and largest seeds. The surface is finely roughened and dull, and the general form varies from nearly spherical to strongly flattened and oval or nearly circular. The color is gray, yellowish, brown, or reddish brown, depending largely on the kind. In contrast, clover and alfalfa seeds are smooth, often with a slight luster. Their triangular, oval, or kidney form aids in distinguishing them from the seeds of dodder.

The use of a sieve with which a considerable quantity of the seed, if in bulk, or all of a sample can be sifted affords the most practical means of detecting the presence of dodder. The sieve should be such that only the smallest or medium-sized crop seeds will pass its mesh. The smaller dodder seeds, such as those of flax dodder, clover dodder, and small-seeded alfalfa dodder, will readily be concentrated to smaller bulk by this means. The large-seeded kinds will be represented by their small seeds. Care should be taken to sift only a small quantity of seed at a time.

As a final resort in case of doubt, examination of the structure of the dodder seed shows it to contain a slender threadlike embryo coiled within the endosperm, which becomes gelatinous when wet. If a few dodder seeds are boiled in water for a time, the embryo emerges from the ruptured seed coat, often becoming separated from it as a slender, coiled object.

DESCRIPTIONS OF DODDER SEEDS.

The seeds of the several kinds of dodder are distinguished by differences in size, form, and surface texture, by the seed scar, and by color. Size and form are modified by the number of seeds developed in the seed vessel. The surface texture varies considerably with the different kinds. The seed scar consists of a more or less distinct circular area surrounding the hilum or immediate point of attachment to the parent plant.

FLAX DODDER.

Individual seeds of flax dodder (*Cuscuta epilinum* Weihe) are much smaller than flax seeds, but a considerable part of this dodder seed consists of two seeds stuck together. This increases the size and weight of the seed and renders it more likely to be retained in the cleaned flax seed. Single seeds are somewhat oval; one face rounded, the other more or less flattened in two planes which slope from a central ridge extending lengthwise of the seed. The scar is a minute whitish point at one end of this ridge, which is flattened. When the seeds are double, they are rounded on one face, practically plane on the other, and angular, oval, or nearly circular in outline. The surface of these seeds is comparatively rough, sometimes even finely scurfy. The color is gray or light brown. Double seeds are about the size of average red clover seeds. (Fig. 2:)

FIG. 2.—Seeds of flax dodder and three seeds of flax, showing relative sizes. Enlarged. (From a drawing by the author.)

The frequent occurrence of double seeds serves to distinguish this kind of dodder from all the others. Again, this dodder is rarely, if ever, found in seed other than flax.

Flax dodder is closely related to the small-seeded alfalfa dodder (*Cuscuta planiflora*) and the seeds of the two kinds are very similar in form. Those of the flax dodder are, however, distinctly larger than the latter.

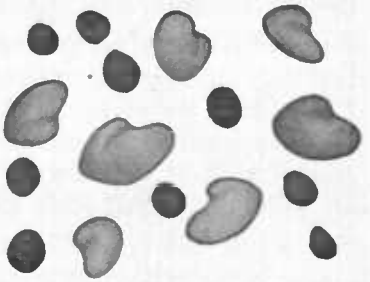

FIG. 3.—Seeds of clover dodder and red clover, showing relative sizes. Enlarged. (From a drawing by the author.)

CLOVER DODDER.

The seeds of clover dodder (*Cuscuta epithymum* Murr) are not larger than the smallest red clover seeds, some of them being even smaller. They are nearly spherical when well developed, but some seeds which

are not well filled are flattened somewhat, even shriveled. The general color is brown, but some seeds are gray. The darker seeds, at least, appear as finely pitted when seen under a lens. The scar area appears as a minute rounded spot somewhat smoother and sometimes lighter colored than the rest of the surface. (Figs. 3, 4, and 5.) Small particles of clay which are likely to occur in clover seed sometimes become rounded by friction, when they very closely resemble clover dodder seeds. Such particles yield readily to slight pressure with a knife blade, under which they crumble to dust.

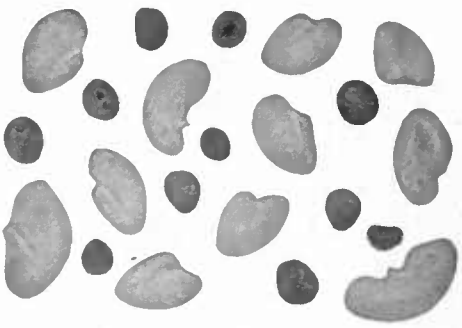

FIG. 4.—Seeds of clover dodder and alfalfa, showing relative sizes. Enlarged. (From a drawing by the author.)

FIG. 5.—Seeds of clover dodder and white clover, showing relative sizes. Enlarged. (From a drawing by the author.)

The use of a sieve allowing only the smallest clover or alfalfa seeds to pass renders the detection of clover dodder very easy.

Clover dodder and the small-seeded alfalfa dodder as impurities of alfalfa seed are likely to be confounded. The clover dodder is distinguished by its more spherical form, pitted surface, and darker or ashy-gray color.

SMALL-SEEDED ALFALFA DODDER.

Seeds of this alfalfa dodder (*Cuscuta planiflora* Ten.) are minute, much smaller than alfalfa seeds. They are therefore readily detected by using a sieve only sufficiently fine to hold practically all of the alfalfa seed. The seeds are oval or oval-oblong, rounded on one face, the other flattened in two planes which meet at a central ridge extending lengthwise of the seed. At one end of the ridge this face is beveled. The resulting area contains the hilum as a minute whitish point. The surface is comparatively rough as viewed under a lens. The color is variable. Some seeds are greenish; others are strongly tinged with purple. As a rule the seeds have a yellowish straw color. (Fig. 6.)

FIG. 6.—Small-seeded alfalfa dodder and alfalfa seeds, showing relative sizes. Enlarged. (From a drawing by the author.)

The oval and angular form and the yellowish or greenish color of these seeds render them readily distinguishable from those of clover dodder.

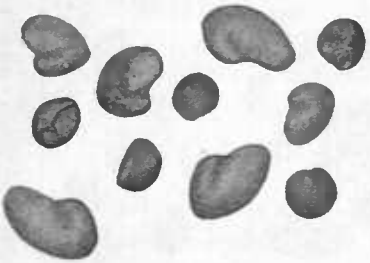

FIG. 7.—Seeds of field dodder and red clover, showing relative sizes. Enlarged. (From a drawing by the author.)

FIELD DODDER.

The seeds of field dodder (*Cuscuta arvensis* Beyrich) are larger than those of any of the preceding kinds, except the double seeds of flax dodder. Their size varies as a rule between that of the smaller and that of average red clover seeds. These seeds are oval or nearly circular in outline, rounded on one face, and variously flattened and angled or deeply grooved on the other. The scar as a rounded area containing a short whitish hilum appears at one end of the flattened face. The color is lemon-yellow, gray, or light brown. (Figs. 7 and 8.)

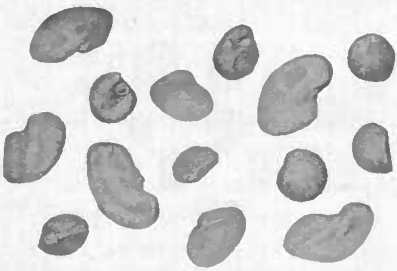

FIG. 8.—Seeds of field dodder and alfalfa, showing relative sizes. Enlarged. (From a drawing by the author.)

LARGE-SEEDED ALFALFA DODDER.

Seeds of this alfalfa dodder (*Cuscuta indecora* Choisy) are similar in a general way to those of field dodder. They appear to show greater variation in size than the other kinds. There is also considerable difference in form. Seeds of a certain size and form therefore are very similar to those of field dodder, but are scarcely to be confounded with seeds of the first three kinds described. The largest seeds are most characteristic of this species. They are nearly circular in outline, but are usually somewhat broader than long—that is, the scar appears to be at one side of the seed, whereas it is really at the basal end. Such seeds are convex on one face and plane or broadly grooved on the other bearing the scar, which is comparatively

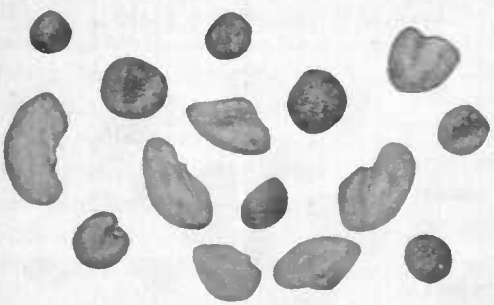

FIG. 9.—Seeds of large-seeded alfalfa dodder and alfalfa, showing relative sizes. Enlarged. (From a drawing by the author.)

indistinct. The color is gray or brown, sometimes very dark. The surface is often very rough or scurfy. These seeds are to be looked for in alfalfa seed from the western United States. (Fig. 9.)

CHILEAN DODDER.

Seed found in South American red clover and alfalfa seed and determined to be of the species and variety *Cuscuta racemosa chileana* Engelm. is larger and usually more plump than seed of field dodder (*Cuscuta arvensis*). It is reddish brown and the surface is often strongly roughened. The most evident point of difference between this and field dodder lies in the scar. The hilum appears as a point-like depression in the center of the circular scar area. In field dodder a short whitish line not depressed represents this part of the scar.

The seeds of this dodder appear to occur at the present time only in South American seed. Along with this seed are found seeds of a different kind, however, which are similar to and perhaps identical with field dodder.

BUYING SEED.

Every purchaser of clover or alfalfa seed in the open market is likely to receive dodder-infested seed unless it has been found by thorough test to be free from dodder. As previously shown, this liability is due to the several kinds of dodder involved, the extensive field of seed production, the custom among dealers of mixing different lots, and the practice of using low-grade imported seed in adulteration. The average farmer has himself to blame for some of these adulterants, which are often employed by dealers to meet the farmer's demand for cheap seed. With respect to dodder, as well as other impurities, cheap seed is always to be looked upon with suspicion and as a rule is to be avoided.

Often seed of local production from fields known to be free from dodder can be obtained. If well cleaned it is preferable to the average seed in the market. Seed from dealers should be bought by sample, accompanied by a time limit within which the dealer agrees to furnish the same seed in bulk. Such samples should be tested for dodder. If tested at a State agricultural experiment station or at the United States Department of Agriculture some delay is sure to result. The test is so simple and so quickly made that the farmer should himself make it, thus permitting an immediate order for the seed if desired.

The responsibility of any test ends with the particular lot sent for test, and the presence of a few dodder seeds in the bulk lot of any seed represented by a small sample is always possible. The ill effects likely to result will be evident in the young stand of the crop.

With regard to the importance of using only dodder-free seed, it may be said that badly infested fields are practically ruined by certain kinds of dodder and that the loss of the crop is proportional to the extent of the infestation. The seed crop is reduced in quantity and quality. The reduced quality of the seed crop is not represented wholly by a dodder-infested crop, but also by the fact that the dodder so reduces the clover plants' food supply that the crop is likely to be of lighter weight than it otherwise would be. Again, dodder seed production is likely to so contaminate the land with seeds that a return to clover or alfalfa may be accompanied by dodder infestation, even though pure seed be used.

The period of seeding probably has considerable bearing on the results from using dodder-infested seed. Spring seeding is most favorable for growth of the dodder. It is an unsettled question whether dodder plants in the field ever live over winter. It appears that very few, if any, survive. In consequence of this fact, summer or early fall seeding, too late to enable the dodder to produce seed, tends to free the crop of the following season from dodder. Considerable damage from the dodder might occur to the seeding, however, during the first season. Furthermore, some dodder seeds might not germinate till the following spring.

CLEANING SEED.

Under certain conditions it may become necessary to remove the dodder seeds from an infested lot of seed in order to prevent its loss. While the average farmer might hesitate to discard a purchase of seed because of its dodder seeds, badly infested seed would be far more profitably discarded than sown without thorough recleaning.

The successful removal of dodder depends on the kinds of seeds involved and their consequent relation respecting size. It is doubtful if alsike and white clovers can be cleaned of dodder, although the amount of clover dodder can be reduced somewhat by the use of proper sieves, which, however, necessitate the loss of considerable clover seed.

Red clover and alfalfa seeds can be cleaned of clover dodder and small-seeded alfalfa dodder by the use of a sieve having 20 meshes to the linear inch and made of wire ranging from No. 30 to No. 34 of Washburn and Moen gauge. This statement is based on experiments with sieves of this mesh made of Nos. 30, 32, and 34 wire. Samples of the above kinds of dodder, as found in commercial seeds and as taken from fruiting plants, were employed in the experiments. Especial attention was given in the trials to the largest of the seeds of these kinds. It was found that either of these sieves will admit all the seeds of these species with proper care in the sifting. If a sieve of this

mesh made of wire coarser than No. 30 of Washburn and Moen gauge is used, the largest dodder seeds of the above kinds will be retained by it; while, if the mesh is coarser than provided by No. 34 wire, there will be an undue loss of crop seed, especially in the case of small-seeded red clover. The loss of alfalfa seed is comparatively small when using any of the sieves recommended. The same is true of the better, large-seeded grades of red clover seed. In the case of the small-seeded grades of red clover the loss of seed when a sieve of No. 34 wire is used may amount to the greater part of the bulk. The sieves made of the coarser wire are better adapted for such seed. Small-seeded grades are usually low-grade screenings which carry small weed seeds, many of which are removed by the sieve.

The farmer may find it difficult to secure the proper sieve. Manufacturers do not carry all of the sizes in stock. The writer has found the 20-mesh No. 30 wire in the stock of one firm and the No. 32 wire in that of another. The other sizes may be carried by other dealers, but from what has been learned these sizes have to be made to special order, and an order for a considerable quantity is demanded.

The efficient use of any of these sieves requires that much care be taken to do thorough work. Only a small quantity of seed should be sifted at a time. The sifting should be continued until all of the seed has been brought in contact with the wire. It is believed that the most effective work will result from using first a No. 34 wire sieve and then passing the siftings thus obtained over a sieve of No. 30 wire.

With respect to the other kinds of dodder discussed in this bulletin and found in clover and alfalfa seeds it may be said that none of the sieves mentioned will remove all the seed, even with repeated sifting. Much of the dodder seed will be removed, especially if a sieve having No. 34 wire is used. Thus far no means of wholly removing these large-seeded kinds is known.

Deep seeding of the crop appears to be the most promising course for the farmer to follow in using seed known to contain seeds of the large-seeded dodders. By this means many of the dodder seeds will be buried too deep to permit their plants reaching the surface. Sifting the seed, by which as much as possible of the dodder is removed, is therefore most advisable.

Flax dodder can be removed from flax with very little loss by the use of a sieve of 14 meshes to the linear inch and made of No 29 wire, W. & M. gauge.

It often happens that seed is retained by unopened dodder capsules, which permit it to remain with the seed held by the sieve.

DETECTING THE DODDER PLANTS IN THE FIELD.

It has been shown that notwithstanding every precaution against the introduction of dodder, seeds may find their way to the field in the seed used. The ultimate control of the plants may depend upon early efforts to discover and destroy them. This is particularly true if the plants appear in few places in the field.

The proper time to destroy the plants is before rapid branching enables them to reach many host plants. Then every firm hold of the dodder suckers becomes a point of independent growth, and the difficulty of reaching all of them is greatly increased. New seedings, therefore, should be carefully examined for this pest.

Under favorable conditions the dodder seeds germinate but little slower than seeds of clover and alfalfa. The young plants therefore appear at about the same time as the clover. Their discovery in the seeding at first is practically impossible. By the time the crop is 6 or 8 inches high the dodder will have branched sufficiently, as a rule, to render its presence noticeable for a short distance. This permits removal of the plants with the least loss to the stand and with the most likelihood of success.

Different kinds of dodder exhibit in the field individual habits well worthy of consideration in detecting their presence, such as low-growing or high-growing tendencies and their manner of spreading from plant to plant.

Field dodder grows to the top of the host plants, throws out its branches, and rapidly extends from plant to plant, often forming a dense yellow carpet of tangled branches covering and bearing down the crop. (Fig. 10.) Small-seeded alfalfa dodder, on the other hand, confines its growth exclusively to the lower part of the host plant, rarely exceeding a foot from the ground. It spreads slowly from plant to plant, confining itself chiefly to the several branches of the individual alfalfa plant. While a patch of field dodder can be seen a long distance, the other, when the stand is at all thick, can be observed for but a few feet.

The habit of clover dodder differs from that of each of the kinds previously described. Its flowering stems usually climb the host stems for a foot or more. The vegetative stems, by means of which the plant spreads to new host plants, form a dense mat, or carpet, close to the ground, winding in and out among the host stems, often completely surrounding them and hiding the ground. In this way the spreading of the plant is rapid and very effective. The early growth of this plant is not readily detected at a distance.

The effect on the crop differs with these different habits of growth. Field dodder destroys its host plants in irregular patches, probably in many instances as much by bearing down and smothering the crop as

by the withdrawal of plant food. All of the crop plants within an infested area are likely to be attacked. Small-seeded alfalfa dodder, confining its attacks chiefly to individual resistant and naturally long-lived plants, eventually causes a general thinning of the stand through the death of scattered individual plants. Healthy, infested, and nearly dead alfalfa plants thus often occur in close proximity.

Clover dodder attacks every clover plant and to a greater or less extent other plants within the infested area. It destroys rapidly, and its progress from the original point of attack is so uniform that dis-

FIG. 10.—Field dodder covering red clover and grasses. From a photograph of an infested field.

tinctly circular areas bared of living clover or alfalfa result. These circular spots of dead plants are very characteristic marks of the destruction caused by this species. A narrow band of living dodder stems will be found bordering the circle of destroyed plants

Flax dodder bears down the flax plants and is therefore sometimes called "pull-down." It also draws the tops of the plants together. Both large-seeded alfalfa dodder and Chilean dodder ascend to the top of the host plant. The former produces dense flower and fruiting clusters; the latter appears to have a more open habit and scattered flower system.

The form and appearance of the flower clusters differ with the different kinds of dodder. Clover dodder flowers are in small compact clusters of several flowers each. The clusters as well as the stems are often tinged with red. Small-seeded alfalfa dodder flowers are in similar clusters which are not colored. Field dodder flowers are in looser clusters scattered among the branches or crowded in bunches.

DESTROYING THE PLANTS.

When failure to prevent the introduction of dodder seed occurs, the destruction of the plants becomes the final resort. The questions of success and the extent of the necessary damage to the crop at once arise. Their answers rest with the kind of crop infested, the stage of development of the dodder, the extent of the attack, and the methods of eradication employed.

The problem of dodder control is strongly influenced by the character of the crop infested. Red clover remains but two, or at most but three, years without reseeding. If the dodder is prevented from seeding it should be eradicated within this time, or at least should not interfere with the course of crop rotation. Alfalfa should remain indefinitely, and if dodder reseeds itself its control becomes much more difficult or impossible. This is the prevailing condition in the West. The fact that the small-seeded alfalfa dodder of the West has not become established in the East is of special interest in this connection. Clover dodder appears likely to prove most troublesome in alfalfa culture in the East.

If the dodder occurs only in patches in the field it usually can be controlled by hand methods. If it covers the greater part or all of the field, plowing under the stand will probably be found necessary. It then becomes important to know how far the crop can be utilized without reseeding the land to dodder.

It is first important to gain control before the plants have spread far from the point of attack; secondly, and of greater importance, they should be subdued before they produce seed. Success therefore depends very largely on early discovery of the plants, followed by immediate work in subduing them. Thoroughness involves the destruction of every living piece of dodder stem lying within its own length of a host plant.

Cutting and burning infested plants and spraying them with copper sulphate or iron sulphate are methods which have been employed. Spraying has not proved successful as a rule, owing to the impossibility of thoroughly wetting every part of the dodder stems under field conditions. The plants have appeared to be destroyed, but a sufficient number remained to continue growth after receiving a temporary check. Burning is successful when thoroughly done.

This may or may not destroy the crop roots. The burning may take place on the infested spot or the cut plants may be removed to be burned elsewhere. Burning on the spot is an advantage, on account of its destroying dodder missed in cutting and seeds which have fallen. Burning endangers the life of the roots of the crop, however. The removal of infested plants to another place requires great care to prevent any of the pieces of dodder falling on the crop and establishing new centers of growth, and the use of sacks or some similar means of removal is advised.

In cutting infested plants care should be taken to carry the work far enough on the borders to include all of the dodder. Cutting close to the ground is equally important. The recognition of the different habits of different kinds of dodder may be helpful in this connection. Small-seeded alfalfa dodder is confined largely to individual plants, and if all these can be located and destroyed there may be little danger of further damage. This plant grows very low, however, and there is little hope of saving the crown of individual alfalfa plants. Field dodder spreads in every direction, but irregularly, and all through the crop plants from their tops to the ground. It may be difficult to determine the borders of an infested patch. All of the infested area should be cleared, but often the stand may be saved. In the case of clover dodder, particularly in an advanced stage, all the plants of a circular area are killed, while the active growth of the dodder is confined to a band of infested plants immediately surrounding this area. Cutting and burning this ring of plants where it falls will probably be found most effective, because the carpet of dodder stems is so dense and so low that its complete removal is practically impossible. Careful examination of the ground may show individual dodder stems creeping a foot or two farther into the crop than otherwise would be evident. Success depends on destroying such stems. Patches of ground cleared of clover by this dodder may contain its seed. Such areas should be burned over to kill this seed before resowing to clover.

The small-seeded alfalfa dodder as a pest of alfalfa in the West is a problem in itself. It has become so widely prevalent that its permanent eradication locally becomes practically impossible in many cases. Not only is much of the seed used in the West likely to contain its seed, but it is readily carried from farm to farm in irrigating water. Bunches of dodder-infested hay fall in various places in the field and along the roadsides, and in this way scatter seeds. Thus conditions are conducive to keeping the fields infested.

Methods of reasonable control of this dodder appear to be more promising in the West than attempts to eradicate it. Observations have shown that low-lying, well-irrigated lands are not infested to the

same extent as the higher and drier lands. It is, therefore, possible that confining alfalfa culture to lands capable of abundant irrigation and destroying the stand of alfalfa on the drier land when infested with dodder will tend to reduce the loss from the pest, even though it may remain.

Plowing should precede the seeding of the dodder. In this way all danger of future occurrence of the pest is averted if all infested plants are covered. If the plowing is delayed until after the dodder develops its seed the crop can be burned over, producing a hot fire before the surface soil is disturbed. This should destroy the greater part of the seeds lying exposed on the surface of the soil and in unopened seed vessels. In lieu of either plowing or burning over dodder-sown ground, shallow cultivation, followed by some crop requiring frequent surface tillage, will tend to keep the seeds near the surface and perhaps lead to the destruction of the greater part of them.

It is believed that as a rule dodder plants will not injure such a cultivated crop. This is doubtless true of clover dodder and small-seeded alfalfa dodder. Certain crops might, however, be injured by field dodder or large-seeded alfalfa dodder. The injury to beets in Utah caused by field dodder, previously noted, and the observations of the writer upon the growth and effect of large-seeded alfalfa dodder on various coarse plants justify the recognition of the possibility of damage from these kinds.

It is important in such surface cultivation that the dodder seeds do not become covered too deep, as it is known that they are capable of remaining alive for several years when buried. In one authentic case at least 16 per cent of a quantity of buried seed germinated at the end of three years.

An infested stand of clover or alfalfa may safely be allowed to produce a crop of hay or be used for pasturage or for soiling provided the crop is removed before the dodder produces seed. The removal of a bulky crop aids in the complete covering of the stubble, which is important. Plowing should follow immediately after the removal of the crop; otherwise mature dodder seeds will be buried and possibly prove troublesome on again being brought to the surface.

Dodder is not poisonous to stock. Hay carrying dense bunches of it is usually pushed aside by stock. The Utah farmer previously referred to as having obtained 60 bushels of dodder seed by recleaning his seed crop stated that he fed this seed to stock without ill effect.

SUMMARY.

(1) Dodder is a parasitic plant dependent on a host plant for its food. It reproduces by means of seeds and from pieces of stems permitted to come in favorable contact with a suitable host plant.

(2) There are several kinds of dodder especially destructive to flax and to leguminous crops.

(3) The dodders exhibit pronounced preferences for certain kinds of host plants, with the result that a crop is not equally subject to injury from different kinds of dodder.

(4) Climatic and weather conditions strongly influence the growth and productiveness of the dodders. Thus, small-seeded alfalfa dodder, so common in the West, appears to be unknown in the Eastern States, and clover dodder produces so little seed in this country that its seed rarely, if ever, is found in American-grown red clover seed or alfalfa seed.

(5) Dodder seeds are a very common impurity of clover, alfalfa, and flax seed in the trade. Certain kinds are more commonly found in domestic than in foreign seed, while the contrary is true of other kinds. Low-grade seed imported from Europe generally contains dodder.

(6) Dodder seeds can readily be distinguished from crop seeds by a seedsman or farmer using a magnifying glass.

(7) Certain kinds of dodder seeds can be thoroughly cleaned from the best grade of farm seed. Other kinds can not be wholly separated from the seed which carries them.

(8) Some dodder seed is likely to escape removal in recleaning, and the young seeding should therefore be examined for dodder plants.

(9) The dodder plants should be discovered early and destroyed by removal or burning.

(10) Dodder plants should not be allowed to seed, thereby contaminating the land.

(11) Hand methods may subdue the dodder plants if they are not too abundant; otherwise plowing under before they go to seed or burning the stand if seeds have already ripened will be necessary.

(12) The early crop of clover or alfalfa preceding the ripening of the dodder seeds can safely be used as pasturage, for soiling, or in hay making. The infested stubble should be plowed under immediately.

(13) The most generally effective means of preventing the introduction of dodder is to use seed free from dodder seeds. The purchasing farmer can easily make a reasonably satisfactory test for dodder seed.

(14) Where irrigation is practiced dodder seed may be carried from place to place in the water used.